The Role of Structural Damping in Dynamic Response

by

Sam A. Kiger

West Virginia University
Morgantown, WV

OUTLINE

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Report Documentation Page

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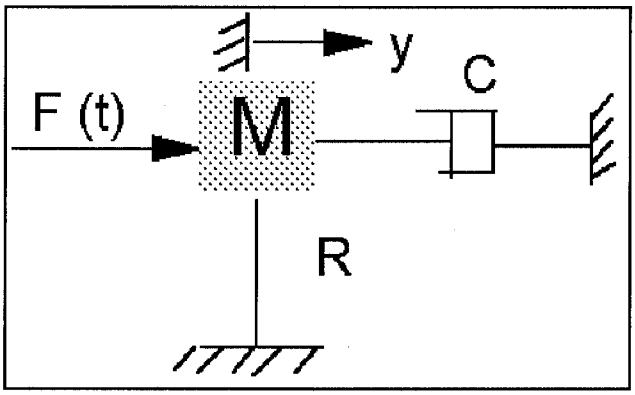
SDOF MODEL



The SDOF "Equivalent" parameters are based on an assumed response (or failure) mode.

$$M\ddot{y} + C\dot{y} + R = F(t)$$

SMI MODEL (SDOF)

Ignore Damping and rewrite the SDOF equation as:

EQUATION

$$\ddot{y} + \frac{r}{\rho d} = \frac{P(t)}{\rho d}$$

Where

r is resistance in force per unit area

p is loading in force per unit area

ρ is mass density

and d is structural thickness

$$P(t) = \sigma_i + \sigma_r$$

$$= \sigma_i + \rho_s C_s \Delta \upsilon$$

$$= \sigma_i + \rho_s C_s (\upsilon - \dot{y})$$

$$= 2\sigma_i - \rho_s C_s \dot{y}$$

Then

$$\ddot{y} + \frac{\rho_s C_s}{\rho d}\dot{y} + \frac{r}{\rho d} = \frac{2\sigma_i}{\rho d}$$

This equation assumes elastic behavior. In fact, the media wave speed, C_S, is difficult to define during plastic response.

DAMPING

Almost all descriptions of damping are derived from a linear SDOF system with a viscous damper in parallel with the spring, and all damping measurements relate to energy loss per cycle of motion.

Several investigators have recommended use of large damping ratios during plastic response calculations, for example:

Hinman and Weidlinger (87)
Drake, et.al. (87 and 89)
Krauthainmer, et.al. (84 and 86)
and Serena (92)

EXAMPLE

Assume a reinforced concrete slab

Maximum Resistance	l00 psi
Peak Load:	300 psi
Load Duration:	4 ms

Damping (Percent of Critical)	Deflection (in)
0	7.4
5	5.9
10	4.9
15	4.3
20	3.7
25	3.3
40	2.5

Damping 25 percent of critical and peak load: 300 psi
and Duration: 4 ms

Max Resistance (psi)	Deflection (in)
100	3.3
50	4.7
10	7.1
7	7.4

Thus, deflection of the 7 psi slab with 25 percent damping is the same as the 100 psi slab with no damping.

Items often neglected in SDOF model:

Loading:

- Non Uniform Loading
- Localized Loading
- Time Phasing of Loading
- Fragment Loading
- Unloading of Reflected Pressure From Openings and Edges

Resistance:

- Two-Way Effects
- Compressive Membrane Action
- Tensile Membrane Resistance
- Rate Effects

Soil - Structure Interaction

- Soil Arching
- Soil Strength

CONCLUSIONS

- Even small amounts of damping can significantly effect calculations in the plastic response region.
- Damping for plastic response can not be defined.
- Experimental or analytical verification for Damping during plastic response is not available.
- Damping should not be used when plastic response is the predominant mode.

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